Appendix 7

Nonroad Mobile Sources - Improved Categories

Post 1990 Improvements to the Nonroad Mobile Emissions Inventory

The following sections provide brief descriptions of projects developed by TCEQ staff and contractors which greatly improved the Nonroad Mobile Emissions Inventory. These descriptions are actual introductory sections from the project documents. Complete documents can be obtained from Emissions Inventory staff at (512) 239-1478.

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COMMERCIAL MARINE VESSELS

Improvements to the Commercial Marine Vessel Emission Inventory in the Vicinity of Houston, Texas

Starcrest Consulting Group LLC
ERG, Inc.

Prepared for the Houston Advanced Research Center (HARC)
July 28, 2003

Executive Summary

In terms of mass emissions for ocean-going ships this report is relatively consistent with the previous emissions inventory used in the Houston-Galveston State Implementation Plan for ozone. However, as more clarity is brought into the inventory, we see a dramatic increase in dwelling NOX with a corresponding and proportional reduction in transit emissions. There are several reasons for the increase in dwelling emissions. First, ships must jockey for a limited number of berths, since the harbor is running near capacity. Second, chemical tankers tend to make many deliveries and take on product at the same time (some chemical tankers have up to 60 double-hulled compartments). Third, ships must wait for orders, inspections and other regulatory requirements that cause them to "shift" within the harbor. Aside from tugboats, which are not updated in this report, results for other miscellaneous kinds of ships fall into marginal categories because their mass emissions are small.

It should be noted that dredging emissions are very high compared to the historical record because of Tropical Storm Allison remediation and two large channel deepening projects. As a result, year 2000 dredging emissions should not be projected into the future without using a negative growth rate.

A weakness of this study was a complete lack of information regarding government and military vessels. As mentioned in the proposal and work plan, recent national security issues may have contributed to this lack, in spite of sending Freedom of Information Act (FOIA) letters. Fishing boat emissions were equally difficult to estimate and were not included in our final totals. Findings from the in-port ships study are reported in Table ES-1.

Table ES-1: Study Findings for In-Port Ships, 2000 Daily Emissions

Emission Type	NOX	VOC	CO
Transit	8.61	1.29	5.56
Dwell	12.12	0.38	1.34
Total HARC	20.73	1.67	6.90
HGAVEI (1997)	20.10	0.60	2.80

This study confirms the previous Starcrest findings regarding ocean-going vessels, updates dredge emissions for the new ozone episodes modeled in the year 2000, and makes some minor recommendations for miscellaneous vessel categories. The VOC and CO emissions were slightly higher than previously estimated, although their impact on ozone models is though to be miniscule. As the same spatial resolution was used as the last marine vessel update, the new values will be easy to incorporate into the ozone model's pre-processing system. Some additional observations and recommendations follow:

Dredge emissions are part of the harbor vessel category, so adjustments may be done by (1) removing 0.75 tons of NOX from the former base case and (2) by adding 10.97 tons back in; however, existing base case emissions (e.g., 0.75 tons of NOX) should be used in the 2007 future case

Beaumont in-port emissions should be updated and added to the emissions inventory because both Houston and Beaumont are modeled as to ozone at the same time, perhaps as a "phase II" effort

Such a second phase would allow for updates to non-port marine vessel emission estimates, especially in parts of the Gulf of Mexico not addressed in the scope of this report; there are also plans to validate all the emission factors and investigate whether a "ton-mile" method would be a better predictor of at-sea emissions

Reducing uncertainty in the existing emissions inventory for ocean-going ships was perhaps the main benefit of the report. The additional dredge emissions may affect the base case photochemical modeling because the numbers are so large. For selected offshore zones, updating ocean-going emissions was another benefit, since those emissions have not been updated in almost ten years.

Introduction

In a continuing effort to help refine the emissions used for the Houston air quality plan, this study attempts to improve upon previous work on commercial marine vessels (CMV). The starting place was the Houston-Galveston Vessel Emissions Inventory (Starcrest 2000), which was based on 1997 ship call data. A “ship call” is defined as an external ship movement, such as from the sea to a dock (internal trips are called “shifts”). The Starcrest report concluded by suggesting several recommendations: refinements to auxiliary engines, additional work on dredging, and more work of ship fuel types. Table 1 reports the main findings of the Starcrest report. All emission reporting units used in this report are short tons American, with 2,000 pounds per ton.

Table 1. 1997 CMV Emissions, Tons per Ozone Season Day [a]

Vessel Type	NO_x	VOC	CO	PM
Ocean-Going Vessel	20.2	0.6	2.8	1.6
Towboat[b]	8.0	0.2	1.2	0.2
Harbor Vessel[c]	3.3	0.1	0.6	0.1
Total	31.5	0.9	4.6	1.9

a. source: *Houston-Galveston Vessel Emissions Inventory*
b. Towboats include tugboat and barge trips.
c. Harbor vessels include most but not all smaller diesel-powered commercial craft.

It should be recognized that military and fishing vessel emissions (SSC 2280003040 and 2280002030, respectively) were not included in the initial Starcrest report. Recreational vessels were likewise not included with harbor vessels (SSC 2280002020) because they are considered under a different source category code (SCC).

The main reason for this report is to support the State Implementation Plan for Texas, since the Houston and Beaumont areas are considered to be in non-attainment of the ozone standards for ambient air quality. The principal user of the data would be the modelers who simulate ozone episodes and the effect of various controls to lower ozone precursors in the attainment year 2007. For this reason the pollutants included in this paper only cover:

Oxides of nitrogen (NOX)

Volatile organic compounds (VOC)

Carbon monoxide (CO)

In the future, when the new particulate matter (PM-2.5) standards are implemented, a closer look at elemental carbon (EC), organic carbon (OC), ammonia (NH3), and sulfur oxides (SOX) would be warranted. The state of the science with respect to PM precursors from ship exhaust is not fully understood. The same can be said about greenhouse gas emissions and toxic air contaminants, most of which are based upon outdated AP-42 information relating to stationary fuel combustion. However, the science regarding diesel-powered ship emission rates of ozone precursors is fairly well understood, at least as far as the emission factors.

The nature of commercial marine vessel operations is somewhat more difficult to characterize, however, since they tend to operate in ways not typical of other sources of air pollution. With the exception of ferryboats, they do not follow known schedules. There is no standard ship size or emission factor, such as is used with highway vehicles (MOBILE6 model). Until relatively recently, most authorities used fuel consumption as a surrogate to estimate emissions – with the obvious problem that large ships can purchase fuel locally and “burn it all the way around the world.” This report relies on what is called the power method, which requires an understanding of available engine horsepower and time in operating mode. The general form of the equation is

$$E = EF * LF * A * c$$

Equation 1

Where

E = Emissions (short tons)

EF = Emission Factor (g/kW-hr)

LF = Load Factor

A = Activity, hours of use

c = conversion from grams to short tons

The geographic scope includes the Houston-Galveston metropolitan statistical area comprised of eight counties surrounding Houston, Texas. The counties that have significant commercial marine emissions are: Harris, Galveston, Brazoria, and Chambers. The Port of Houston includes the sub-ports of Houston, Texas City, and Galveston. The Port of Freeport is a separate port located east of Galveston on the Gulf Coast. The seaward extent of county emissions is 12 nautical miles out to sea,[1] although there are several rather confusing definitions of federal versus

[1] The 12-mile territorial limit was authorized the Presidential Proclamation 5928 (December 27, 1988).

state waters.[2] For the purposes of this report, a 9-mile federal limit was used because this is where oceanic ships slow down or stop to pick up port pilots, who actually drive the ships into their berths. Note that the 9 to 200 nautical mile zone is therefore considered as federal waters.

The ports of Beaumont and Port Arthur were added to the study because their shipping routes within federal waters are intertwined with those from Houston, including a major lightering area (lightering occurs when a large crude oil tanker transfers product to a smaller tanker, since the large tanker is too long or has too much draft to enter the port). This was done so as to make it easier for TCEQ modelers to update their offshore emissions inventories, since lack of traffic from Beaumont would significantly underestimate the zone totals.

[2] The nine-mile natural resources limit was authorized by Public Law 83.31 (67 Stat 29, March 22, 1953) that only applies to Texas, Florida, and Puerto Rico; other states and territories have a 3-mile boundary.

AIRCRAFT

1996, 1999, and 2007 Airport
Emissions Inventory

by

Texas Transportation Institute

Technical Note 402011-8
Research Project Number 402011-8
Research Project Title: Air Quality Planning and Assessment, Airport Emissions

Sponsored by the
Texas Natural Resource Conservation Commission

March 2000

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

BACKGROUND

Section 176(c) of the federal Clean Air Act Amendment (CAAA) requires that major federal actions must conform to the State and Federal Implementation Plans promulgated under Section 110 of the CAAA, a review process called general conformity. This task examines airport-related emissions, since they are regulated by the U.S. Federal Aviation Administration (FAA). General conformity may be triggered at airports located in nonattainment areas if indirect and direct emissions are above stated thresholds (e.g., 25 tons per year of nitrogen oxides [NOx] due to constructing an additional taxiway).

Given that the new ozone standard promulgated on July 17, 1997 may include new nonattainment areas, the geographic scope has been expanded to include large commercial and general aviation airports located in the eastern part of Texas. This includes airports east of Interstate 35. The purpose of this task is to improve the accuracy of the 1996 county-level emissions inventory for aircraft and airport emissions for all counties. The Texas Natural Resource Conservation Commission (TNRCC) previously prepared a 1996 aircraft emissions inventory for some counties. This task will enhance the 1996 inventory by providing improved aircraft specific activity data for estimating aircraft emissions and collecting other airport related activity data for estimating airport related emissions. Activity projections were made for 1999 and 2007 and emissions were estimated. This Technical Note provides TNRCC with aircraft and airport-related emissions for 1996, 1999, and 2007.

Aircraft emissions are believed to comprise less than 2% of the mobile source NOx emissions inventory, but they are significant contributors to the NOx inventory in some cities. In addition, commercial aircraft emissions are a fast growing segment of the transportation emissions inventory. Aircraft emissions are potentially important contributors to global climate change and may also contribute to the depletion of the stratospheric ozone layer.

Emissions standards for gas turbine engines that power civil aircraft have been in place for about 20 years. Such engines are used in virtually all commercial aircraft, including both scheduled and freight airlines. The standards do not apply to military or general aviation aircraft. Controls on engine smoke and prohibitions on fuel venting were instituted in 1974 and have been revised several times since then. Beginning in 1984, limits were placed on the amount of unburned hydrocarbon (HC) gas turbine engines can emit per landing and takeoff cycle.

In April of 1997, the U.S. Environmental Protection Agency (EPA) adopted the existing International Civil Aviation Organization (ICAO) NOx and carbon dioxide (CO) emissions standards for gas turbine engines. ICAO, a specialized agency of the United Nations, is the most appropriate forum for first establishing commercial aircraft engine emissions standards due to the international nature of the aviation industry.

The EPA is also exploring other methods to reduce the environmental effects associated with air travel throughout the nation. The EPA is working with the FAA to encourage continuing progress in reducing emissions produced by airport ground service equipment and aircraft auxiliary power units. The EPA sponsored a project to compile technical data and emissions inventory methods that the FAA will use to develop an Advisory Circular for airlines and airport authorities interested in reducing emissions from these sources.

The format of this document corresponds to the list of deliverables outlined in the aviation portion of the transportation air quality technical support work plan document. It includes the following:

- technical note describing general aviation 1996, 1999, and 2007 activity measure estimates by airport, the aircraft emissions estimates, and the identification of those general aviation airports with significant other emissions sources;

- computer file listing the emissions by type for each general aviation airport and the gridded emissions by county;

- technical note describing the progress of developing the emissions inventories for each military base with significant flight operations and providing a work plan for completing the inventory; and

- technical note describing the progress of developing the emissions inventories for the 27 commercial service airports in Texas.

PREPARATION OF 1996, 1999, AND 2007 GENERAL AVIATION AIRPORT EMISSIONS INVENTORY

INTRODUCTION

This report documents the methodology and procedure used for preparing both annual and average ozone season day aircraft emissions inventories for all general aviation airports with 10 or more based aircraft. The 1996 emissions were estimated, and the 1999 and 2007 emissions were projected.

EXHAUST EMISSIONS ESTIMATION

Emissions and Dispersion Modeling System (EDMS) Method

The Emissions and Dispersion Modeling System (EDMS) was not used for general aviation airport emissions inventory estimations in this project. The EDMS, jointly developed by the FAA and the U.S. Air Force (USAF) for airport emissions estimation, requires aircraft-specified and engine-specified operations data. Unlike the commercial service airports, most general aviation airports do not have this detailed information available. Therefore, the EDMS is not suitable for estimating emissions for general aviation airports.

Alternative Fleet Average Procedure
As introduced in EPA's publication entitled, "Procedures for Emission Inventory Preparation," Chapter 5, "Emission from Aircraft," of Volume IV, "Mobile Sources," an approximate estimate of exhaust emissions for each aircraft category can be obtained using emissions indices based on a representative fleet mix. The following indices based on 1988 fleet data for general aviation aircraft were presented in Section 5.2.4.2 of the EPA report. One aircraft LTO is equivalent to two aircraft operations (one landing and one takeoff).

HC	0.394 pounds per landing and takeoff (LTO) cycle;
CO	12.014 pounds per LTO;
NOx	0.065 pounds per LTO; and
Sulfur Dioxide (SO_2)	0.01 pounds per LTO.

The following generalized factors, like those mentioned above for general aviation aircraft operations, are for air taxi aircraft where turboprop and turbojet aircraft exist in the fleet. They are:

HC	1.234 pounds per LTO
CO	28.130 pounds per LTO
NOX	0.158 pounds per LTO
SOX	0.015 pounds per LTO

These factors were used to represent the larger aircraft operations at Fort Worth Alliance Airport and Fort Worth Meacham International Airport. This is discussed in more detail later in the report in the section on commercial service airports.

The above indices were adopted in exhaust emissions estimations for general aviation airports in this project.

EVAPORATIVE EMISSIONS ESTIMATION

Emissions From Diurnal Temperature Changes
The following equation, introduced in Appendix D of EPA's publication entitled, "Air Quality Procedures for Civilian Airports & Air Force Bases," was used for quantifying HC evaporative emissions from general aviation aircraft fuel venting in this project.

$$E_T = 0.15 \text{ lbs./day/based aircraft} \times A_b \times D$$

Where:
E_T = total HC emissions, in pounds, resulting from diurnal losses;
A_b = number of aircraft based in the region of interest; and
D = number of days in the period of interest.

Emissions From Pre-Flight Safety Checks

The emissions from pre-flight safety procedures were also included in the evaporative emissions of this project. The following equation for pre-flight safety check emissions was also introduced in “Air Quality Procedures for Civilian Airports & Air Force Bases.”

$$E_T = 0.20 \text{ lb}/LTO_L \times LTO$$

Where: E_T = total HC emissions, in pounds, resulting from pre-flight safety checks; and

LTO_L = number of LTO cycles by piston-engine aircraft during the period of interest, excluding LTO cycles by itinerant aircraft.

To calculate emissions from pre-flight safety checks, the number of local operations by piston-engine aircraft is needed. Since the detailed operation data by aircraft type was not available for general aviation airports, estimates were made using the nationwide data from the FAA. According to the FAA’s “General Aviation and Air Taxi Activity Survey, 1996,” piston-engine aircraft comprised 83% of local operations. The survey showed that 70% of total operations were local operations. Therefore, locally operated piston-engine aircraft made approximately 58% of total operations (Table 1). This number was used to estimate emissions from pre-flight safety checks.

Refueling Loss

There are evaporative emissions that result from refueling general aviation aircraft and from fuel spillage. The EPA methodology for calculating refueling losses was provided in an EPA Office of Air and Radiation memorandum from Mary Manners to Susan Willis dated October 20, 1996; Subject: Revised Methodology for Calculating the Refueling Losses for General Aviation Aircraft. The calculated refueling and spillage loss of an aircraft was 4.61 grams of HC per gallon of fuel consumed.

Fuel consumption per aircraft was estimated to calculate the emission from refueling. The Texas Transportation Institute (TTI) recently completed the fuel consumption analysis for the Texas airport system plan forecast (see Texas Airport System Plan Technical Note).

CONSTRUCTION EQUIPMENT

Houston/Galveston Area

Development of a Revised Emissions Inventory for Construction Equipment in the Houston-Galveston Ozone Non-Attainment Area

FINAL REPORT

APRIL 20, 2000

Prepared for

The Houston-Galveston Area Council and the TNRCC Area and Mobile Source Emissions Assessment Section

Prepared by

Eastern Research Group, Inc.

Starcrest Consulting Group, LLC

INTRODUCTION

Under contract with the Houston-Galveston Area Council, Eastern Research Group, in conjunction with Starcrest Consulting conducted a detailed survey of construction equipment populations and activity within the 8 county Houston ozone non-attainment area.[1] As part of this effort, Starcrest Consulting was instrumental in facilitating communications with a coalition of local construction trade organizations, the Houston Construction Industry Coalition, and assisting with the development of survey strategies. The cooperation of industry representatives was crucial to the success of this effort as well.

Based on the study's findings, input files were generated for use in EPA's NONROAD emissions model in order to estimate total pollution levels from construction sources operating in the area. These results serve as an update to TNRCC's previous estimates based on EPA's default

[1] Counties include Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller.

methodology.

TNRCC staff recently ran the NONROAD model using the revised input files to develop a revised construction emissions inventory for the Houston area. The draft results are summarized below for emissions of nitrogen oxides (NOx), a key pollutant in ozone formation in Houston.

Table 1
Summary of Houston Construction Source NOx Emissions Estimates for 2007

Data Source	NOx (TPD)
EPA Default (NEVES)	101.6
Houston area study	32.1*

*Note that the results include estimates for landfill, mining and logging equipment developed independently by the TNRCC.

Based on these findings, EPA's default methodology significantly overestimates total emissions from construction sources operating in the 8 county Houston area. Overall contributions to ozone formation from this sector are likely to fall as well, pending the results of future Urban Airshed Model runs.

The following sections provide a brief discussion of background issues, an overview of the study's general methodology and assumptions, detailed discussions for each construction sector evaluated, a summary of the study's findings, and recommendations for additional improvements to the inventory.

BACKGROUND

The 8 counties in the Houston-Galveston region are currently designated as a severe ozone non-attainment area. As such, USEPA requires the Texas Natural Resource Conservation Commission (TNRCC) to adopt aggressive, stringent emission control strategies in order to bring the area into attainment with the National Ambient Air Quality Standards by 2007.

In order for the TNRCC to develop an effective control strategy for Houston, a detailed inventory is required for all emission sources in the area. Detailed assessments have been performed previously for both stationary and on-road mobile sources, using locality-specific data. For this reason population and activity levels for these sources are considered relatively accurate.

However most non-road source inventories, such as those for construction and industrial equipment, rely on "top-down" methods to estimate equipment populations and usage. Specifically the current estimates for non-road equipment populations in the Houston area are based upon EPA's 1991 Nonroad Engine and Vehicle Emissions Study (NEVES). The NEVES was developed from the Power Systems Research (PSR) national database of engine sales and populations, as well as from confidential manufacturer reports. The key parameters used to calculate NOx emissions for each equipment type include:

equipment population;
average horsepower rating;
average engine load factor;
annual hours of operation; and,
emission factors.

For the NEVES EPA estimated county level equipment populations by allocating the national level data, using construction activity surrogates from the Census Bureau's County Business Patterns Report of 1991.[2] For further details concerning the NEVES data please see Appendix A.

For several reasons it is believed that the NEVES significantly overestimates equipment populations (and therefore emissions) for the construction sector in Houston. For example, Houston serves as headquarters for some of the world's largest construction companies, with thousands of employees dedicated to engineering and administrative work. However, the employment surrogates found in the County Business Patterns Report do not distinguish between "office" and "field" employees. While the number of construction field employees in a given area may be indicative of overall construction activity, projections using total "construction employment" in the Houston area may drastically overestimate overall equipment numbers and activity. (Similar problems also arise with the F.W. Dodge data on construction valuations – see footnote 2.)

For these reasons a "bottom-up" survey of construction sources in the area could provide significant improvements to the equipment inventory. However, previous survey attempts encountered very low response rates, and ultimately proved unsuccessful.

As part of a multi-task contract with the Houston-Galveston Area Council, Eastern Research Group agreed to perform a comprehensive survey of all construction equipment activity in the 8 county area. In order to improve survey response rates, ERG obtained assistance from a coalition of several local trade organizations, termed the Houston Construction Industry Coalition (HCIC). The HCIC, along with their representative Starcrest Consulting, was instrumental in identifying key experts for interviews, as well as encouraging their member companies to actively participate in the survey effort. Table 2 lists the key trade organizations participating in the effort, along with their associated constituents. The table also lists key points of contact for additional survey sectors not represented by the HCIC

[2] EPA currently believes this allocation scheme can be improved, and uses "dollar value of construction" estimates from the F.W. Dodge database in the NONROAD emission factor model currently under development.

Table 2

Principal Contributors to Data Gathering -- HCIC and Other Participants

Organization/Point of Contact	Associated Sector
Associated General Contractors of Texas	Highway / Municipal Utility / Commercial
Associated Builders and Contractors of Houston	Industrial
Houston Contractors Association	Municipal Utility
Greater Houston Builders Association	Residential
Harris County, Judge's Office	Municipalities and Counties
Harris County Tax Assessor's Office	Rental
Equipment Purchasing Manager, TXDOT	TXDOT Equipment
Reliant Energy, Substation Construction Dept.	Utility Extensions

These organizations were also instrumental in developing the final survey and QA strategy, described in the following section.

LOCOMOTIVES

Starcrest Consulting Group, LLC
ERG, Inc.

August 30, 2002
Version 4.0

Executive Summary

Large railways operating in Texas were asked to supply their gross ton-miles of rolling stock as well as the number of their switch engines. Resulting emissions are roughly consistent with previous work done for the 1990 Base Year Emissions Inventory. Estimates were generated for the entire state as well as the Houston-Galveston region. The statewide results are summarized in Table 1 below.

Table 1. Statewide Locomotive Emissions (Tons), 2001

	HC	CO	NOx	PM
Annual	2,512	6,433	62,213	1,596
Ozone Day	9.4	24.0	231.9	6.0

These results do not justify the use of an alternative "top-down" fuel consumption method, that would approximately double the amount of emissions. Future work using new modeling tools, such as those proposed by TTI, is needed to bring additional clarity to this major component of the air quality emissions inventory.

Introduction

There are three Class I railways operating in Texas: Union Pacific (UP), Burlington-Northern Santa-Fe (BNSF), and Kansas City Southern (KCS). In addition, the Port Terminal Railroad Association (PTRA) and the Texas-Mexico Railway (TMR) were also considered "major railways" for the purposes of this study. Other railways including Class II operations and excursion trains were not included as their emissions are thought to be relatively insignificant. Emissions are updated for the entire state, with special attention to the Houston non-attainment area.

Locomotive Activity Survey

The Texas Natural Resource Conservation Commission (TNRCC) officially requested information from the three Class I railways. Letters and contacts were established in May, June, and July of 2002. The UP and BNSF included gross ton-miles (GTM) for the line haul locomotives, as well as the number of switch engines. [This was provided at the county level, correct? If so, please note.] This information was then converted to gallons of fuel consumed, using existing guidance from the U.S. Environmental Protection Agency (EPA) [Please provide reference].

The KCS data required further clarification through telephone contacts conducted in August of 2002. The situation with KCS is complex because they have an agreement with TMR regarding its Corpus Christi-Laredo railway line in South Texas. However, the TMR operating data for GTM is not recorded in the KCS computer systems, since these statistics are currently recorded by Transportacion Ferrovaria Mexicana (TFM). Therefore, as a surrogate for this activity we modeled line-haul locomotive emissions as switch engines (n=38).

Further surveys were conducted for the PTRA, which operates approximately 24 switch engines[1] in the Houston area, particularly along the Houston Ship Channel. The PTRA has track usage agreements with the UP, BNSF, and TMR, but PTRA switch engines are also used to assist with operations at six railway yards serving approximately 150 industrial facilities.

Emission Factors

Fuel consumption was used to estimate emissions in terms of grams of pollution per gallon of diesel fuel, being based upon EPA emission factors associated with the 1997 Locomotive Rule.

The emission factors used in this paper are based upon an industry average for the year 2001, without any difference between line-haul and switch engines. The emission rates are presented in Table 2 below.

Table 2. 2001 Industry Average Emission Factors, Grams per Gallon of Diesel Fuel

HC	CO	NOX	PM
10.7	24.7	265.0	6.8

Actual, in-use emission rates could vary, especially with particulate matter (PM-10), since particulate is a function of diesel fuel properties (e.g., sulfur content) as well as duty cycle

1 The PTRA estimated that it consumed 1,348,289 gallons of diesel in 2001 (email with John Conrad, PTRA, August 26, 2002).

(acceleration, lug, and deceleration). However, railways are very sensitive to any perceived State interference, such as by suggesting in-use opacity readings that could be used to supplement or refine these national average emission factors.

It should also be noted that switch engine emission factors could be higher compared to line-haul emission rates, often as much as 50 percent higher. We anticipate higher emission rates for switch engines because (1) they tend to be older, two-stroke diesels and (2) because their stop-and-go duty cycle creates higher loads and therefore NOx emissions than when operating at cruise speeds. For example, baseline NOx emission rates for switch engines were 362 grams per gallon, as compared to 270 for line-haul locomotives. [Sam, please cite source.] However, given the complexities of the Locomotive Rule (63 FR 18978, April 16, 1998), which allows flexibility on the part of railroads to meet compliance targets, it was decided to use the fleet average emission rates contained in the emission factor guidance (EPA420-F-97-051, December, 1997), which includes all types of locomotives.

Emission Estimation Procedure

As stated above, gross ton-miles (GTM) was furnished without modification by UP and BNSF, and the KSC data was revised based on their documented railways and total GTM. The BNSF used a conversion factor of 762 GTM per gallon of diesel fuel. The UP used a conversion factor of 722 GMT per gallon. The KCS did not furnish GTM fuel consumption statistics so the larger number (762) was used for their operations. As a result, we estimate196.6 million gallons of fuel consumed on main lines in Texas in 2001.

Switch engines were treated slightly differently, based solely on per unit fuel consumption estimates. The BNSF assumed that switch engines would consume approximately 82,490 gallons per year; the UP assumed that each switcher would consume 83,220 gallons per year. These statistics may have been derived from the 1991 mobile source emissions inventory guidance from the U.S. Environmental Protection Agency (both railways claimed that these were EPA defaults used to estimate switch engine fuel consumption). Given the similarity of the two estimates (less than 1% difference), the average of the two factors, 82,855 gallon of diesel per year, was used for all switch engines in Texas including the TMR surrogates and the PTRA. Based on these assumptions, 16.3 million gallons of diesel fuel was consumed by switch engines in Texas in the year 2001.

Line haul plus switch engine fuel demand summed to 212.9 million gallons per year. The EPA emission factors were then applied to subtotal gallons of diesel consumed in a given county. No corrections for county allocations were required except in the case of the TFM in South Texas.

After annual emissions were estimated, typical ozone season emissions were calculated as a fraction of annual emissions. This was difficult to glean from the railways' data, since they had different schedules depending on the route, load type, and company. Since railways do curtail operations during weekends and holidays, it was decided to use a seasonal activity factor (SAF) of 268.25 (365.25 days minus the weekends in a year, without respect to holidays). This reflects the reasonable assumption that a typical ozone season weekday would have higher emissions than by dividing by 365 days in a year. Detailed calculations are included in the Appendix [*Locomotive(1).XLS*]. Note that the SAF can be easily changed at the request of the TNRCC.

Findings

Statewide we found the following totals by pollutant, as is shown in Table 3.

Table 3. Statewide Locomotive Emissions (Tons), 2001

	HC	CO	NOx	PM
Annual	2,512	6,433	62,213	1,596
Ozone Day	9.4	24.0	231.9	6.0

Emissions of sulfur dioxide (SO_2) were not estimated because, while it can be approximated using a mass balance equation, the EPA does not have published grams-per-gallon emission factors for this pollutant. Ozone season day emissions were also computed for the Houston area. Table 4 reports the emissions in terms of tons per day.

Discussion

There is considerable question about the fuel sales and fuel consumption statistics used in this analysis, since the U.S. Department of Energy has published locomotive diesel sales figures close to 504.4 million gallons (2000).

The DOE estimate is more than twice what we found in our survey (212.9 million gallons). Bear in mind, however, that these are fuel sales statistics, not fuel consumption data. It could well be that fuel sales information gathered using Energy Information Administration form EIA-821 could be bulk locomotive fuel purchases that were transported elsewhere, although this conclusion is not supported by any hard evidence. Based on the locomotive GTM and switch engine survey, further, there does not seem to be any justification to double the activity or emissions, although one could make a case that line haul locomotive idling could consume an additional five to ten percent. Nevertheless, future work should attempt to identify the source of this discrepancy.

This does not unequivocally validate our revised locomotive emissions estimates, however, since there is considerable controversy regarding the number of switch engines, fuel consumption, and GTM. For instance, railways report GTM and fuel purchases to two different federal agencies and the numbers do not appear to match each other using engineering and accounting principles.

OIL FIELD EQUIPMENT

TCEQ

Staff

2002

This category is defined as equipment located at oil and gas exploration (well drilling) sites. Examples of equipment include large diesel generators that operate drilling functions at the sites. The NONROAD model calculates emissions from this category using “number of employees” as the activity surrogate. The employee number is obtained from the Census Bureau’s “County Business Patterns document which provides the number of employees by NAICS (formerly SIC) codes associated for business in each county. The problem with this method was discovered when emissions from oil field equipment in Harris County (Houston) was compared with emissions from equipment in Gregg County (Longview). A second comparison was made for actual oil and gas production for the two areas. The results showed that although Gregg County had much greater production than Harris County, Gregg County had fewer emissions associated with Oil field equipment. It was determined the Census was including employees not directly involved with field work (e.g., oil company office workers) in the NAICS description. Since Houston has several offices housing oil industry employees the NONROAD model was giving inflated emissions for Harris County.

In order to provide more accurate emissions for this category, the NONROAD model methodology was replaced by use of a more accurate surrogate – actual oil and gas production data. This includes data from the active producing wells for each county. The total statewide emission rates from the NONROAD model were prorated to county levels using this production data rather than using employee numbers. For the 2002 Periodic Emissions Inventories actual drilling rig counts will be used as the surrogate.

RECREATIONAL BOATS

Recreational Marine Emissions Inventory

Starcrest Consulting Group
ERG, Inc.

August 28, 2002
Version 4.0

Executive Summary

Use of a geographic information system (GIS) and a revised database of boat registrations improved upon the modeled air quality emissions inventory for recreational marine engines. The difference between the default NONROAD model (version 1.2) output is quite striking, as shown in Table ES-1.

Table ES-1. Summary Findings, Texas, 2001
Tons Per Day

Scenario	VOC	CO	NOx
Default NONROAD Model, Weekday	75.0	139.5	4.1
Improved GIS Model, Weekday Emissions	151.1	288.4	4.8
Improved GIS Model, Weekend Emissions	592.9	1,682.1	28.2

Results indicate much higher hydrocarbon emissions than what would be output by the default model, especially when one considers the "weekend effect," which could include holidays such as July 4^{th}. The second goal of the project was to allocate these totals across the 254 Texas counties using a travel demand equation. By using a geographic information system (GIS), a

new matrix was generated based on boat registrations, water body acreage, and travel distance. The GIS proved to be an effective tool for outputting values that can be used in allocating regional emissions. However, as indicated in the concluding section, the model would benefit from a regression analysis that also considers inputs such as condition of the water body (flooded, drought, or normal) and level of "amenity attractance" (reputation for fishing, recreation, and other attitudinal inputs).

Introduction

As its name suggests, the recreational marine vessel (RMV) category excludes commercial marine vessels (CMV). While it is true that some CMV engines appear in the Texas Parks and Wildlife Department (TPWD) boat registration database (the basis for the population estimates in this analysis), their number is few and they tend to be small vessels under 60 of length, as opposed to the ships, ferries, and dredges, which can be up to 1,000 feet in length. While RMV engines emit very little as compared to their CMV counterparts, the RMV category is comprised of hundreds of thousands of engines that can add up to be a significant source of air quality emissions, especially on the larger lakes, bays, and other public water bodies.

Emission Estimation: Total Mass

The NONROAD model version 1.2, once updated with the new RWV population count data, was used to estimate emissions from:

a. Personal watercraft
b. Inboard gasoline engines
c. Inboard diesel engines
d. Outboard gasoline engines
e. Outboard diesel engines

The source of the revised RMV county-level population was from the TPWD and was obtained through the Texas Natural Resource Conservation Commission (TNRCC). The TPWD requires registration of all RMV craft except for small rowboats and non-powered sailboats. Their population list was then modified to be consistent with the NONROAD input file structures. Statewide totals were:

TPWD: 617,602
NONROAD default: 336,829

Based on these totals, one would expect that emissions would roughly double as compared to the default settings – a significant achievement in advancing the emission inventory science for non-road sources in Texas. Note that most of the NONROAD internal settings regarding model year distribution and horsepower category profiles were not modified, since we did not have reliable local data to do so. The number of boat registrations has a direct impact on the amount of emissions – if you double the amount of boats, all other things being equal, then you will have twice the emissions.

The NONROAD model version 1.2 was used to estimate emissions. The input was calibrated to average ozone season day temperature swings, although for this analysis the gasoline volatility (Reid Vapor Pressure, RVP) was assumed to be 7.8 RVP. Future model improvements for gasoline volatility would include setting Dallas, Houston, and El Paso areas to 6.8 RVP, as well as relaxing western Texas counties to approximately 8.4 RVP. It should be noted that evaporative emissions are a major source of volatile organic compound (VOC) emissions, so a more accurate portrayal of in-use RVP could change countywide emissions, but are not expected to change the statewide total mass of VOC emissions on a substantial basis.

[It should also be recognized that the U.S. Environmental Protection Agency (EPA) is revising its NONROAD model to better model emissions including those from RMV (proposed NONROAD2002 model), as part of its latest rulemaking package regarding recreational vehicles and engines. This model adds gasoline tank and fuel line permeation emissions to the computations, and modifies some of the algorithms regarding evaporative and exhaust emission rates. Unfortunately the EPA has not released the new model version to the public so the ultimate impact of these changes is uncertain.]

Modeling files are available in the electronic version of this report. For the sake of simplicity, the following file naming conventions were used:

RECMARD: ozone season analysis using default EPA allocations
- RECMAR: ozone season day analysis using new TPWD inputs
- RECMARA: annual period total for the year 2001
- RECMARW: ozone season weekend analysis (useful for air quality modeling)

The next step in the process, a major goal of this project, was to allocate the RMV population (and hence the emissions) to the 254 Texas counties, as is explained in the next section.

AIRPORT GROUND SUPPORT EQUIPMENT

Houston Area

MEMORANDUM

ASHWORTH LEININGER GROUP

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To: Scott F. Belcher, Esq.

From: Ev Ashworth and Dan Godden

Date: May 25, 2000

Re: Revised ATA GSE Emission Estimate – Houston/Galveston Nonattainment Area

This memorandum provides the nitrogen oxide (NOx) emission inventory for Ground Service Equipment (GSE) operations at the three major airports located within the Houston/Galveston nonattainment area:

Ellington Field (EFD)
William P. Hobby Airport (HOU)
Houston Intercontinental Airport (IAH)

This memorandum follows the format of our earlier correspondence to you regarding the Dallas/Fort Worth Nonattainment Area (see ALG memo dated March 13, 2000). Based on the emission inventory approach summarized below, our NOx emissions are estimated as follows:

GSE Data Set	Number of Units		Estimated NOx Emissions (TPD)	
	1996	2007	1996	2007

ATA Member Survey Only (Assumes 80% of Pop.)	1,506	2,523	3.06	4.52
Estimated Total Population	1,883	3,154	3.83	5.65

Based on the data posed by the Texas Natural Resources Conservation Commission (TNRCC), 100% electrification of GSE operating at all the commercial airports is expected to reduce NOx emissions by 8.26 tpd in 2007. Thus, the ATA NOx emission estimate is approximately 32% lower than that assumed by TNRCC in its ozone modeling analysis (5.65 tpd versus 8.26 tpd).

We understand from prior discussions with TNRCC that a similar approach was used to generate the Houston GSE data as was used to generate the Dallas/Fort Worth GSE estimates. ALG has not reviewed these inventory data in detail with TNRCC, nor have we requested or obtained any supporting data from TNRCC. If the TRNCC used a similar approach to develop GSE emissions estimates, this would mean that TNRCC relied in part on the EPA Nonroad Engine and Vehicle Emissions Study (NEVES). As explained in our March 13 memo, NEVES is flawed as it includes terminal tractors operating at ports and freight yards in the airport GSE population estimates. Additionally, as explained in our March 13, 2000 memo, the reported activity levels are higher than the NONROAD model assumptions (upon which NEVES was based), and fuel distribution reported by ATA participants provides significantly more gasoline use than estimated by the NONROAD model. Further comparisons between the ATA and TNRCC data may be made once we better understand the basis for the TNRCC estimate.

Summary of the Revised ATA GSE Emissions Inventory

ATA has worked with its members to gather the following GSE data from the three airports in Houston/Galveston area:

a. Population by category of GSE used in 1996
b. Fuel type for each GSE
c. Horsepower for each GSE
d. Model year for each GSE
e. Activity for each GSE
f. Estimated annual growth for all operations through 2007

We obtained data from all ATA member carriers with the exception of Trans World Airlines. Consistent with the ATA emissions inventory for the Dallas/Fort Worth area, data gaps were treated as follows:

Population: Where 1996 population data were not provided, carriers used current populations, which, as operations have increased over the past 4 years, are conservative.

Fuel type: Where fuel type data were not provided, we adjusted these missing data to be consistent with the ratio of gasoline:diesel:CNG that was determined by GSE category in the ATA Southern California GSE inventory (i.e., approximately 30% diesel). The default ratios in the NONROAD model were not used because they reflect a higher percentage of diesel engines than does the recent ATA member data.

Horsepower, Activity, Model Year: Where these data were not provided, we applied the average values by GSE category as determined in the ATA Southern California GSE inventory. The Southern California GSE inventory was exhaustive, and provides the most accurate usage data available. In any event, relying on the NONROAD default assumptions for these inputs will result in lower overall emissions.

Growth: ALG applied a growth factor of 4.8 percent per year, which is the default annual growth factor applied in the EPA NONROAD Model for total GSE for the period of 1996 to 2007. Over the 11 year period (1996-2007), this translates to 67.5% more GSE by 2007. This value is higher than assumed for the Dallas/Fort Worth area.

The data recently provided by ATA members are provided in the attached spreadsheets (with the exception of growth estimates, which is confidential business information). To generate emissions estimates, ALG used the EPA NONROAD predictive model, and substituted the average ATA values for population distributed by horsepower and fuel type, activity by fuel type, and growth. The EPA NONROAD Model emission factors and average load by fuel type were then applied to these ATA data to generate total NOx emissions. The EPA NONROAD model was used, as it is the only model available to estimate emissions in 2007 based on current engine control requirements that apply to operations in Texas.

Based on these data, we provide the following summaries:

Summary of GSE owned by ATA members by Airport - 1996

Houston Intercontinental:	1,225 Units (81% of total)
Ellington Field:	27 Units (2% of total)
Hobby	254 Units(17% of total)

Summary of ATA Emissions Data

Year	Number of GSE	NO_x Emissions (Tons/Day)	Average NO_x Emissions per GSE (Pounds/Year)
1996	1,506	3.06	1,483
2007	2,523	4.52	1,308

The 2007 emissions were generated by adjusting the default NONROAD model growth indicators for GSE to be consistent with the expected 4.8%/year default growth rate.

The ATA population data for the three airports indicate that there are approximately 1,506 motorized GSE at these airports in 1996, not including TWA, non-ATA carriers, the airport operations, and fixed base operators. We estimate that inclusion of the operations not represented by the survey could increase the GSE total by as much as 25%. This 25% value is based on a comparison between ATA member operations and all GSE operations at Los Angeles International Airport in 1995, and was also applied to the Dallas/Fort Worth ATA emissions estimates. The projected total 2007 populations and emissions, scaled from the refined NONROAD results, are summarized below.

ATA GSE NOx Emission Estimates
for Three Major Airports in the Houston/Galveston Area

Year	Number of GSE	NO_x Emissions (Tons/Day)
1996	1,945	3.83
2007	3,154	5.65

LAWN AND GARDEN EQUIPMENT

DEVELOPMENT OF COMMERCIAL LAWN AND GARDEN EMISSIONS ESTIMATES FOR THE STATE OF TEXAS AND SELECTED METROPOLITAN AREAS

FINAL REPORT

Prepared by

Eastern Research Group

Starcrest Consulting Group

Prepared for

Texas Commission on Environmental Quality

November 24, 2003

Introduction

In 2002 the Texas Natural Resource Conservation Commission (now the Texas Commission on Environmental Quality, TCEQ) tasked Eastern Research Group (ERG) to develop emission inventory estimates for portable gasoline containers, recreational marine engines, and lawn and garden equipment operating in Texas (TNRCC Contract # 582-0-34730, Work Order # 34730-02-42). As part of this Work Order, ERG and its subcontractors Starcrest Consulting and NuStats, developed and administered surveys to assess ownership and operation patterns for lawn and garden equipment across the state. ERG and Starcrest used the survey results to estimate ton-per-ozone season weekday emissions of VOC and NOx emissions for commercial uses of this equipment. Subsequent work performed by ERG for the Austin area Capital Area Planning Council (CAPCO) revised and updated the results of the initial analysis. This report describes the survey process, as well as the updated methodology and assumptions used in calculating the emission inventory for lawn and garden equipment in Texas.

Methodology

This study was designed to refine and update the default NONROAD2002 model file for population counts for commercial lawn & garden equipment (TX.POP). These equipment categories are defined in the NONROAD model. The categories include two and four stroke gasoline engines used in the following applications:

a. Lawnmowers
b. Rear riding mowers
c. Front mowers

d. Chainsaws
e. Commercial turf equipment
f. Tractors[1]
g. Leaf-blowers
h. Chippers / grinders
i. Tillers
j. Shredders
k. Edgers/Trimmers
l. Other lawn and garden equipment

ERG developed surveys to determine information on both gas can and lawn and garden equipment ownership and use in Texas. NuStats developed a random call list for all Texas companies listed under SIC 0782, Lawn and Garden Services, for the commercial sector survey. Industry experts confirmed that this service sector segment should account for the vast majority of commercial lawn and garden equipment use in the state. SIC 0781, Landscape Counseling and Planning, and SIC 0783, Ornamental Shrub and Tree Services, were expected to have negligible use of these equipment types.[2] (Note that golf course operation – SIC 7992 – and municipal ownership and use of this equipment, while expected to be quite small relative to SIC 0782, could be evaluated in the future to refine the current population estimates.)[3]

The survey asked for the following information:

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[1] Lawn and garden tractors are a distinct category in the NONROAD model but were not explicitly called out in the NuStats survey. Tractors were placed in either the "rear riding" or "other" categories in this survey.
[2] Personal communication, Marilyn Good, Texas Nursery and Landscape Association, August 2002. (A possible exception is commercial turf equipment use in SIC 0783 – see discussion below.)
[3] Early attempts were made to include golf course maintenance services in the survey but were ultimately not completed due to time constraints.

Primary counties of operation

Details on gas can ownership and use

Number of pieces of equipment for each category

Fuel/engine type for this equipment (2-stroke/4-stroke/diesel)

Details on fuel use rates

Estimated annual revenue

Surveys were conducted by phone between September 2 and September 17, 2002. 125 commercial surveys were completed during this time. Survey totals by equipment category and fuel type are presented in the table below:

Table 1

Texas Commercial Lawn and Garden Equipment Survey Totals

Category	2-Stroke	4-Stroke	Diesel
Lawn Mowers	455	94	0
Rear Riding Mower	144	55	0
Front Mowers	74	1	12
Tillers	47	23	0
Chain Saws	496	9	0
Trimmers	543	3	0
Blowers	403	13	3
Chippers	12	38	3
Commercial Turf	6	1	1
Other	14	0	0

In many cases the surveyed fuel splits between 2-stroke, 4-stroke, and diesel were not consistent with the allowable NONROAD categories. For example, 83% of the surveyed lawn mowers were purportedly 2-stroke, although the NONROAD model defaults indicate 100% 4-stroke for this category. (This is an artifact of the NONROAD model's aggregation of 2 and 4-stroke populations for certain small spark ignition engines.) Other instances of this sort of aggregation include rear and front mowers, chainsaws, chippers, commercial turf, and "other" equipment categories. In these cases the surveyed split between 2 and 4 stroke populations could not be used, and all spark ignition equipment was placed in the allowable NONROAD category. Survey results were used for the overall split between gasoline and diesel equipment when sub-sample sizes were adequate (i.e., for tillers, chainsaws, trimmers, and blowers). All other categories used the NONROAD defaults to split surveyed populations across gasoline and diesel categories.

The NuStats survey was limited in one key regard: certain equipment greater than 25 hp were not included. This exclusion was limited to leaf blowers, chippers/grinders, commercial turf, and other lawn and garden equipment. In order to estimate equipment populations greater than 25 hp for these categories, the ratio of the surveyed populations and the default NONROAD populations under 25 hp were used to scale the NONROAD populations (> 25 hp). In the case of diesel chippers, the TX.POP file does not list *any* engines less than 25 hp, so this approach could not be applied. Therefore the NONROAD defaults greater than 25 hp were used unadjusted for this category.

Commercial survey totals were scaled up to the state level using the total number of firms registered with the Texas Comptroller's office under SIC 0782 in 2002 (8,797/125 for a scaling factor of 70.4). The scaled survey results were combined with the default values specified above to create a new, state-wide NONROAD POP file for commercial lawn and garden equipment. Population estimates were allocated across horsepower bins according to the default NONROAD distributions. In addition, county level Texas Comptroller data for SIC 0782 was used to generate a new ALO file for NONROAD as well.

Survey Results

In general the survey results found substantially lower equipment populations than predicted by the NONROAD2002 model (see Table 2 below).

Table 2

Comparison of Estimated State-Wide Equipment Populations from Survey and NONROAD2002 Defaults

Category	TX.POP	Survey	Difference
Lawn Mowers	109,814	38,636	35%
Tillers	42,041	4,926	12%
Chainsaws	52,696	35,681	68%
Trimmers	134,308	38,496	29%
Blowers	76,388	29,839	39%
Rear Mower	3,512	14,005	399%
Front Mower	43,689	6,193	14%
Tractor	28,507	0	0%
Chippers	3,270	3,800	116%
Turf	72,352	563	1%
Other	52,705	18,446	35%
Totals	619,282	190,585	31%

On average, population estimates fall to approximately 1/3 of their previous value. (Note this reduction is consistent with findings from the Houston construction equipment survey developed for the TRNCC in 2000.) A few categories require further explanation however. First note that the Rear Mower category is almost 4 times *larger* in estimated size than the NONROAD defaults. This is likely explained by the fact that the NuStats survey lumped all lawn and garden tractors into this category.

Commercial turf equipment estimates also merit discussion, at just 1% of the default value. At the time of the survey EPA had not provided a well-defined description for this category. Consequently, survey respondents were not provided with a clear definition. Accordingly, much of this equipment may have been inadvertently assigned to other categories. In addition, it is possible that the exclusion of SIC 0783, Ornamental Shrub and Tree Services, might have also excluded commercial sod grass companies which would be users of commercial turf (but not other lawn and garden) equipment. Future evaluations should investigate contacting commercial sod grass companies to resolve this issue.

Emissions Estimates

The revised TX.POP and ALO files were provided to the TCEQ for use in NONROAD2002 to run with typical ozone season day temperatures and fuel properties. Outputs will generate revised, area-specific emissions estimates for the commercial lawn and garden sector, for both the 1999 base year and 2007 future control year.

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